Instrument Development Group
Tom Reeves - Senior Electronics Engineer
Department of Physics and Astronomy
3400 North Charles Street, Baltimore, MD 21218
Phone (410) 516-7124 FAX (410) 516-6664
Web http://idg.pha.jhu.edu

Description

The incident beam cryogenic filter assembly is located after the beam shutter. It contains three beam filters orientated vertically. Each filter is separated by neutron absorbing material. The neutron beam intercepts one filter at any given time. The filters are maintained at cryogenic temperatures in a vacuum dewar. The recommended method of cooling the filters will employ a closed cycle cryorefigerator. An alternate method of cooling the filters is by use of a liquid nitrogen refrigeration system. The desired filter will be positioned in the beam by the vertical positioning of the dewar.

Requirements

1. Each of the three filters when in position shall encompass the diverging rectangular shaped neutron beam having a height of 20 cm. and a width of 18 cm at the surface of the filter.

2. The three filters shall have:

   a. A 8 cm beam path length single crystalline sapphire grade B4 or better (Crystal System Inc.).

   b. A10 cm beam path length Be grade I-220-H (Brush Wellman).

   c. A 8 cm beam path length pyrolytic graphite grade ZYH (Advanced Ceramics).

3. All filters shall be cooled to a temperature of 77 K or below while dissipating a maximum power of 60 watts due to beam propagation through filter.

4. Filter substrate dimensions will be defined by a specification control drawing created by IDG and approved by the cognizant project management team.

5. Filter substrates will be procured and furnished to IDG by NIST.

6. Positioning of the filters shall be accomplished under computer control.

7. The vacuum dewar shall be fabricated from aluminum (6061-T6 alloy). The dewar walls shall be optimized in the direction of beam propagation over the beam footprint to minimize attenuation and scatter.

8. Volume between the filter substrates shall be filled with neutron absorbing material.

System Description:

The proposed design will position one of three filters with respect to the neutron beam emerging from the beam shutter located outside the biological reactor shielding. The filter materials shall be single crystalline sapphire grade B4 or better 20 cm high x 20 cm wide with a path length of 8 cm, beryllium grade I-220H 20 cm high x 20 cm wide with a path length of 10 cm. and pyrolytic graphite grade ZYH 20 cm high x 20cm wide with a path length 8 cm. The filter substrates shall be procured and supplied to the project by NIST. With the exception of the creation of the drawing that defines the interface control to the filters, the procurement of the filter substrates is not coasted in this study.

The filter assembly will be orientated vertically and housed in an aluminum dewar. The individual filters will be sandwiched between an aluminum parallel plate assembly that will mount to the cryorefigerator cold head. The parallel plates will be tensioned with respect to each other and the captured filters by means of spring loaded transverse fasteners. The tensioning mechanism will provide compliance to compensate for mechanical stresses caused by thermal gradients during the cool down cycle. Each filter will be shielded from its adjacent filter in the vertical plane by neutron-absorbing borated aluminum. The filter assembly will be orientated so that the beam is parallel to the parallel plates that retain the filters and mount to the cold head. This orientation will yield an unobstructed path for the beam through the filter in the direction of beam propagation. The neutron beam filtering will be selected by vertically positioning the filters with respect to the neutron beam emerging from the beam shutter. Positioning of the filters will be accomplished by positioning of the dewar in the vertical plane with respect to the beam shutter.

The dewar will be housed in an assembly consisting of a support housing and a closed loop servo-actuated linear slide cradle assembly. The linear slide cradle assembly will be implemented with off the shelf linear motion components including shafts, shaft supports, linear bearings, bearings blocks and ball screw. The off the shelf components will be mounted to the aluminum support structure using stainless steel fasteners. This method of construction yields precision linear motion assemblies with a minimum of machining. The linear slides will be positioned by a 1.000 inch diameter, 0.250 inch lead ball screw and matching ball nut with mounting flange. The lead screw ballnut combination has accuracy of .004 inches per foot. The lead screw and ball nut are off the shelf items. The lead screw will be coupled to a stock right angle gear box using a universal coupling. The input shaft of the gearbox will be coupled coupled to a dual shaft brushless D.C. motor. A brake will be mounted to the rear shaft of the motor. The motor will be controlled by an off the shelf brush less DC motor controller. Home position of each of the filters will be detected by a combination of micro switches and position sensors. The closed-loop servo system will position the linear slide cradle assembly with respect to the neutron beam emerging from the beam shutter. The vertical position of the cradle assembly will determine the filter that the neutron beam transverses. Required precision and repeatability will be achieved by the use micro switches / hall effect sensors. The positioning system will contain safety interlocks and emergency stop capabilities. The positioning system will be under automatic computer control. The control system will also report the filter position status. Manual operation of the positioning system will be provided for calibration and servicing. The support housing will include an interface at the entrance beam aperture to secure the housing to the shutter in the vertical plane. It will also have adjustable leveling pads to adjust the vertical height of the housing for precise height alignment to the beam shutter. The base of the support housing will have pre-defined hole patterns to secure the assembly in the horizontal plane. Hole patterns to mount removable casters for moving the assembly for servicing and maintenance will also be provided in the base.

The filters shall be cooled using a closed-cycle cryorefigeration system. The temperature of each of the three filters will be monitored in at least two locations using thermocouples and displayed and recorded using a data acquisition system capable of being interfaced to a computer system for data logging. Heaters will be implemented on the filter mounting assembly to control the rate of cooling and induced thermal stresses in the filters. The closed cycle cryorefigerator eliminates the need for replenishing the cryogenic cooling fluid. The system also provides a more controlled cooling compared to a liquid cooling system. Cryogenic cooling spills are also eliminated with the cryorefigerator. The estimated initial time using the closed cycle cryorefigerator is four hours. Estimated service intervals for the system is 6,000 hours. In the event of the implementation of a liquid nitrogen cooling system, liquid nitrogen will be supplied from a 160 liter storage dewar container using a closed loop auto- fill system which monitors liquid nitrogen level in the cooling vessel and maintains the appropriate level by activation a of liquid nitrogen rated solenoid valve. When the system is in steady state operation it will consume liquid nitrogen at the rate of 1.33 liters per hour. Assuming a 160-liter storage dewar, will require changing at 120 hour intervals. Redundant systems will be implemented to reduce the probability of accidental liquid nitrogen spillage. The liquid nitrogen will be piped from the bulk container to the cooling vessel by use of flexible vacuum insulated stainless steel sheathed transfer pipe. The transfer pipe will accommodate the vertical movement of the dewar. The estimate time to cool the filters using the liquid nitrogen system is two hours.

In the implementation of the closed-cycle cryorefigeration system, a cold head that attaches to the dewar will be required in place of the liquid nitrogen cooling vessel contained in the dewar. An external compressor will also be necessary to operate the cold head. Gas lines will connect the compressor to the cold head in place of the liquid nitrogen transfer pipe. Gas lines up to twenty feet can be employed enabling the compressor to be located at up to a twenty-foot radius from the filter assembly. The bulk liquid nitrogen storage container and the liquid nitrogen auto-fill system will not be necessary.

The dewar the will be under vacuum. Vacuum will be supplied to the dewar filter chamber using a commercially available combination dry scroll roughing pump in conjunction with a turbo pump. The vacuum pump will be connected to the dewar using stainless steel flex lines and a normally closed solenoid vacuum valve. The vacuum lines can be up to fifteen feet in length enabling the vacuum pump to be located at a radius of fifteen feet from the vacuum pump. Vacuum will be monitored locally using both a Pirani gauge and a Ion gauge.The outputs of both gauges will also be interfaced to the system computer for monitoring and data logging. Required servicing intervals for the vacuum pump will be at two thousand hours.

Figure 1 shows the filter assembly employing a liquid nitrogen cooling system. Figure 2 shows the filter assembly employing a cryorefrigeration cooling system.

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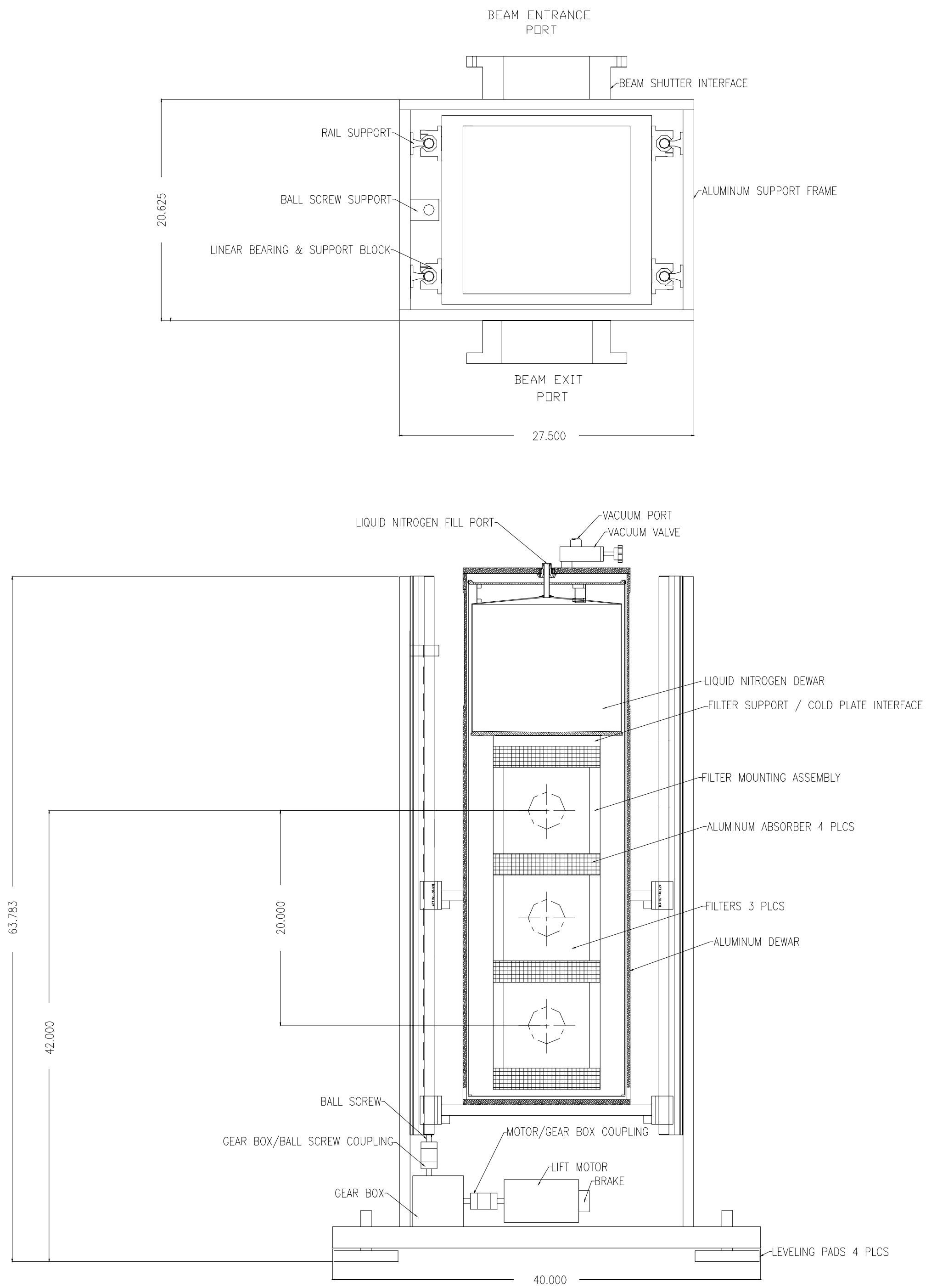

FIGURE 1
FILTER ASSEMBLY USING LIQUID NITROGEN REFRIGERATION

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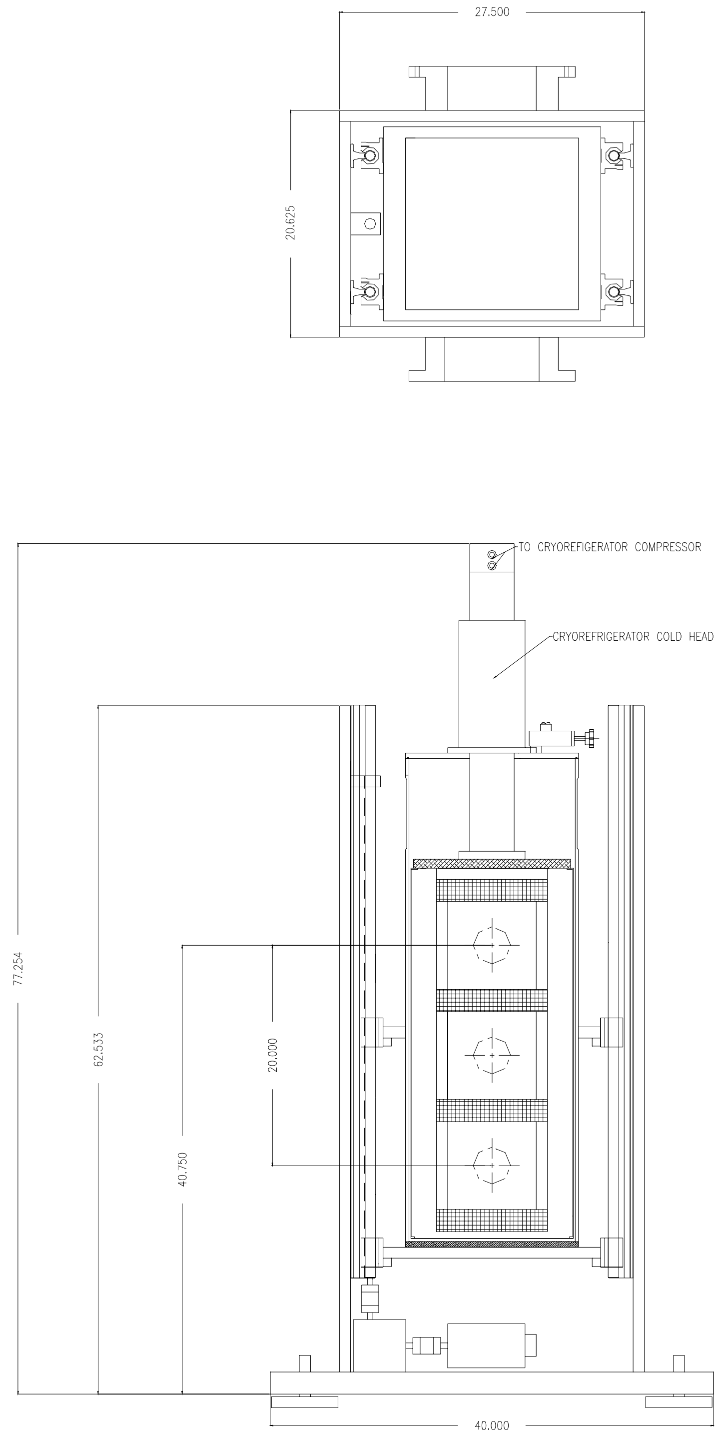

FIGURE 2

FILTER ASSEMBLY USING CRYOREFRIGERATOR

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The following is intended to provide an estimate of the cost and time required to design, build, test, install and integrate the MACS Incident Beam Cryogenic Filter Assembly using presently available information and conceptual definition. Tasks involving IDG labor are at a rate of $51 per hour.

System Tasks

1. System engineering and management	375 hrs. $19,125
2. Filter interface control document	75hrs. $3,825
3. Design of filter holder assembly	100hrs. $5,100
4. Thermal testing evaluation of filter holder assembly	100 hrs. $5,100
5. Design of dewar	325 hrs. 16,575
6. Dewar manufacturing engineering coordination	150 hrs. $7,650
7.Performance testing of dewar system	100 hrs. $5,100
8. Design of dewar support housing	150 hrs. $7,650
9. Design of filter positioning system	100 hrs. $5100
10. Performance testing of filter positioning system	60 hrs. $3,060
11. Mechanical interface control document	40 hrs. $2,040
12. Design of system mechanical interface	80 hrs. $4,080
13.Electrical interface control document	60 hrs. $3,060
14.Design of system electrical interface	120 hrs. $6,000
15.Software design	150 hrs. $7650
16. Performance testing of electrical /software interface	150 hrs. $ 7650
17. Design / testing of refrigeration system	100 hrs. $5,100

18. Design / testing of vacuum system	65 hrs. $3,315
19. Design / testing of temperature monitoring system	65 hrs.$3,315
20. Composite system test under temperature and vacuum	100 hrs. $5,100
21. System installation, integration and test	250 hrs. $12,750
Total System Tasks Hours	2665 hrs. $135,915

PurcPurchased Component

1. Position Control System Components

a. Motor Controller	$650
b. Lift Drive Motor	$350
c. Limit Switches	$150
d. Position Sensors System	$ 450
e. Miscellaneous components	$250
f. Procurement	$1,875

2. Linear Motion Mechanical Components

a. Support Rails and Shafts	$1,204
b. Pillow Blocks and Bearings	$927
c. Couplings	$60
d. Gear Reducer	$250
e. Brake	$225
f. Ball Screw, Nut and Flange	$ 504
g. Miscellaneous	$200
h. Procurement	$1,530

3. Temperature Monitoring System

a. Multi Channel Temperature Monitor	$1245
b. Temperature controller	$1,500
c. Calibrated Temperature Sensors	$1,400
d. Wire	$125
e. Thermocouple feed thru	$350
f. Procurement	$1,020

4. Vacuum System

a. Dry Scroll Pump	$4,905
b. Turbo Pump	$7,604
c. Turbo Controller	$2,002
d. Electromagnetic Valve	$810
e. Ion gauge	$157
f .Pirani Gauge and Controller	$620
g. Miscellaneous Plumbing	$910
h. Vacuum Line	$1,500
i. Procurement	$1,530
Purchased components subtotal	$34,303

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5. Dewar System (Liquid Nitrogen)

a. Dewar	$32,000
b. AutoFill / Monitoring System	$1,455
c. Liquid Nitrogen Transfer Line	$1,800
d.Procurement	$3,060
Dewar system (liquid nitrogen) total	$38,315

5a. Dewar System (Closed – Cycle Cryorefrigerator)

a. Dewar	$36,000
b.Cryorefrigerator	$30,250
c. Procurement	$3,060
d.Dewar System (cryorefrigerator) total	$69,310

6. Fabrication Expenditures

a. Machining	$10,200
b. Material	$2,200
c. Miscellaneous Hardware	$2,550
e. Mechanical assembly	$6,375
f. Electrical assembly	$5100
g. Procurement	$2,550
Fabrication expenditures subtotal	$28,975

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Total System Cost

System Using Cryorefrigerator Dewar (baseline system)	$268,503
System Using Liquid Nitrogen Dewar	$237,508

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